Thrips in Florida Strawberry Crops[1]

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Introduction

Strawberries grown in Florida are attacked by several arthropod pests, including flower thrips. Western flower thrips (*Frankliniella occidentalis*) (Fig. 1) and common blossom thrips (*F. schultzei*) are invasive species of thrips that have the potential to cause damage to strawberries in Florida (Pinent et al. 2011; Mossler 2013). Florida flower thrips (*F. bispinosa*) is a species of thrips native to Florida that is commonly found in strawberry blossoms. This species has the ability to cause economic damage to blueberries; however their ability to cause economic damage to strawberry has not been established (Rhodes et al. 2012; Frantz and Fasulo 2013).

Thrips are small insects ranging from 1 to 4 millimeters in length. They have piercing-sucking mouthparts which are used to ingest the cellular liquids of plants (Hunter and Ullman 1989). The life stages of thrips in the suborder Terebrantia include the egg, larva I, larva II, prepupa, pupa, and adult. The female terebrantian thrips possess a saw-like ovipositor which is used to insert eggs into the foliage of a host plant. Larval and adult thrips are typically found feeding in concealed spaces of the plant and the prepupal and pupal stages are found in the soil (Morse and Hoddle 2006).

Thrips have a short generation time. At 77°F it takes 10 to 16 days for these flower thrips to develop from an egg to adult. As the temperature gets cooler the amount of time it takes to reach adulthood increases (Milne and Walter 1997; MacDonald et al. 1998; Bi-Song 2001). Thrips populations have the potential to increase rapidly. For example, a Florida flower thrips female can produce over 120 eggs in her life time at 77°F when developing on *Alocasia cucullata* leaves and cattail pollen (Bi-Song 2001). A western flower thrips female can lay over 80 eggs in her lifetime at 77°F when feeding on pepper pollen and sucrose (Nielson et al. 2010). A common blossom thrips female is able to produce about 60 eggs at 77°F when fed a larval diet of *Malvaviscus arboreus* and sucrose (Milne et al. 1996). Information about thrips reproduction on strawberry is lacking. Thrips are able to reproduce without mating. Most species are arrhenotokous, which means males are produced from unfertilized eggs and females from fertilized eggs. Thrips can disperse rapidly by taking advantage of air currents to colonize new areas (Lewis 1991; Kumm and Moritz 2009).

Many thrips have a wide host range. However, not all plants are suitable for reproduction of thrips. Pepper is an example of a good reproductive host for both western flower thrips and Florida flower thrips, and tomato is an example of a poor reproductive host (Brodbeck et al. 2001; Avila et al. 2006). High numbers of thrips adults may still be found feeding on poor reproductive hosts, for example when migration into the field is high (Funderburk et al. 2013). Some examples of weeds that may be found around Florida strawberry fields that are hosts to thrips are *Bidens spp.* (Spanish needle) and *Raphanus raphanistrum* (wild radish). Note that the majority of the thrips in these weeds

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in Florida are *Frankliniella bispinosa*. The beneficial predator *Orius spp.* (minute pirate bug) is also commonly found in *Bidens* spp. (Frantz and Mellinger 1990; Eger et al. 1998; Bottenberg at al. 1999; Rhodes and Liburd 2011).

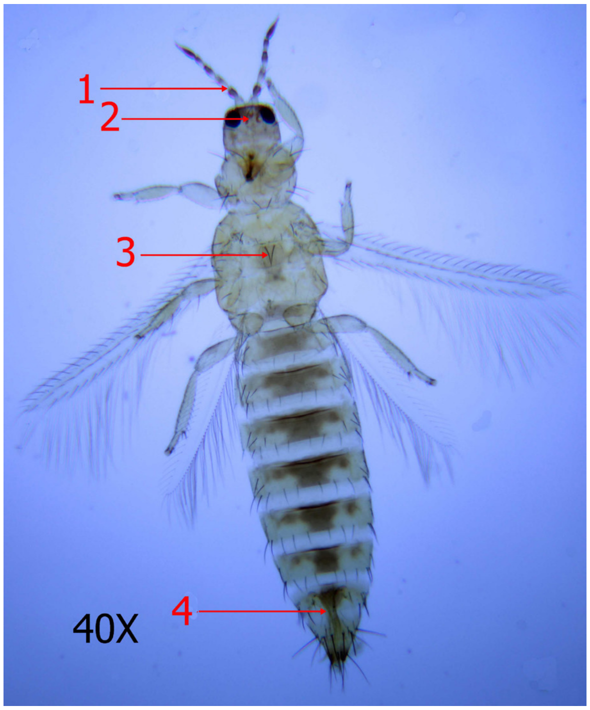

Figure 1. Western flower thrips adult female. (*Frankliniella occidentalis*) Arrow 1 indicates location of antennal characteristics (see Figs. 3 and 4); Arrow 2 indicates location of interocular setae (see Fig. 6); Arrow 3 indicates location of metanotal campaniform sensillae (see Fig. 7); Arrow 4 indicates location of microtrichial comb on tergite VIII (see Fig. 5).
Credits: JD Cluever

Damage

Less than 2% of known thrips species are considered pests. Most of these pest thrips are in the family Thripidae. In strawberries, thrips are implicated in causing flower and fruitlet abortion, petal browning, necrotic flecking, and distorted, bronzed fruit (Fig. 2). Feeding on the flowers can cause withering of anthers and stigmas, resulting in non-uniform fertilization which produces malformed fruit. Feeding on the fruit may result in cracking, bronzing, and a reduction in fresh weight (Coll et al. 2005; New Brunswick 2014; Zalom et al. 2014). Bronzing can also be caused by factors other than thrips including cyclamen mites and spray applications (Polito et al. 2002).

Thrips numbers can be quantified easily by examining flowers from the field. Scouting can be accomplished in different ways. One method is to use a 10X hand lens to examine the blooms for the presence of thrips. Another method is to place a sample of blooms in alcohol and then count the numbers with the use of a microscope (Frantz and Fasulo 2013). However, recommended action thresholds for thrips vary widely from as low as 3-11 per flower to as high as 50 per flower for various species (Steiner and Goodwin 2005). It is not easy to determine which species of thrips are present in a field. However, different species may differ in their ability to inflict damage.

Figure 2. Thrips damage to strawberry.
Credits: H. A. Smith

Frankliniella bispinosa (Florida Flower Thrips)

This species is believed to be native to Florida and it is found in Florida, Georgia, Alabama, the Bahamas, Bermuda, Colombia, Mexico, Japan, Taiwan, and Trinidad (Hoddle et al. 2012; Martin et al. 2012) . It is the most common species in many crops (including strawberry) and weeds in central and south Florida. This species is also found in abundance in north Florida but is less dominant than the eastern flower thrips (*F. tritici*). Problems may occur when high numbers of these thrips migrate from citrus groves following bloom or from oak trees. When treatment is necessary, insecticides that have short residual activity are recommended (Frantz and Fasulo 2013).

Frankliniella occidentalis (Western Flower Thrips)

This species is a native of western North America, but has spread throughout the world. It was first discovered in Florida in the early 1980's (Kirk and Terry 2003). This species is known to be a pest of many crops worldwide. It is most common in north Florida, but is present throughout the state. This species can be difficult to control due to its tendency to develop resistance to insecticides. Its prevalence may increase when broad-spectrum insecticides such as pyrethroids are used. Difficulties managing western flower thrips may be due to resistance to insecticides, reduction in numbers of predators like *Orius* sp., or the removal of *F. bispinosa* as a competitor (Hansen et al. 2003; Frantz and Fasulo 2013).

Frankliniella schultzei (Common Blossom Thrips)

This species is native to Africa but is now found throughout the world in the tropics and subtropics. In Florida this species is most prevalent in the southern portion of the state (Galen Frantz, unpublished data). Incidence is more frequent when broad-spectrum insecticides such as pyrethroids are used (Frantz and Fasulo 2013). Both the brown and yellow morphs exist in Florida, although the dark morph is more common.

Minor Thrips Species

Frankliniella fusca (tobacco thrips) is found occasionally in central Florida strawberries; however, it is more prevalent in the northern portion of the state. *Scirtothrips dorsalis* (chilli thrips) may damage strawberry in some years (Galen Frantz, unpublished data). *Thrips tabaci* (onion thrips) is also found occasionally in strawberries. Another species encountered on occasion is the spider mite predator *Scolothrips pallidus* (Gilstrap and Oatman 1976).

Characteristics to Distinguish Among *F. bispinosa, F. occidentalis* and *F. schultzei*

- 1. Pedicel of third antennal segment flange-shaped (Fig. 3a, Fig. 5c); Setae arising from second antennal segment forming thick, heavy spines (Fig. 4a); Microtrichial comb on tergite VIII well developed and interrupted in center (Fig. 5a, Fig. 5d)……………………*Frankliniella bispinosa*
- 1'. Pedicel of third antennal segment smooth (Fig. 3b, Fig. 3c); Setae arising from second antennal segment not forming thick, heavy spines (Fig. 4b); Microtrichial comb on tergite VIII well developed and not interrupted or not well developed (Fig. 5b, 5d)……………………… Go to 2
- 2. Interocular setae (commonly referred to as Ocular III setae) arising far apart (Fig. 6a); metanotal campaniform sensillae usually present (Fig. 7a); Microtrichial comb on tergite VIII well developed (Fig. 5b, 5d)……*Frankliniella occidentalis*
- 2'. Interocular setae arising close together (Fig. 6b); metanotal campaniform sensillae absent (Fig. 7b); Microtrichial comb on tergite VIII not well developed (Fig. 5c, 5d)……… *Frankliniella schultzei*

Control

Many methods of control exist for thrips including cultural, biological, and chemical. Cultural controls include using UV-reflective mulch and reducing the amount of nitrogen applied to the crop (Stavisky et al. 2002). UV-reflective mulch has been successfully used in tomato for reduction of thrips that vector plant disease (Funderburk et al. 2013).

Biological control includes the use of predatory mites and insects to reduce the population of pest thrips. Agents such as minute pirate bugs (*Orius insidiosus*) and predatory mites (*Amblyseius swirskii*) can be useful for controlling thrips populations and are commercially available (Arthurs et al. 2009).

Naturally occurring thrips predators in Florida strawberry fields include minute pirate bugs, ladybird beetles, lacewings, and predatory mites. Insecticide application decisions for thrips management in strawberry should take into account the presence of naturally occurring natural enemies and the species of thrips present.

Chemical control is another option available for the management of thrips populations. Please see Table 1 for a partial list of insecticides registered for control of thrips on strawberry in Florida. Thrips can often be difficult to control effectively with insecticides because their cryptic behavior limits their exposure to contact insecticides (Hansen et al. 2003). Flower thrips may be protected from systemic insecticides as there may be a lack of uptake into floral tissues (Cloyd and Sadof 1998). Thrips populations also display a great ability to build up resistance to insecticides (Jensen 2000). Resistance of *Frankliniella occidentalis* has been reported to insecticides in several chemical groups including the organochlorines, carbamates, organophosphates, neonicotinoids, pyrethroids, avermectins, spinosyns, and the phenylpyrazoles (Race 1961; Imamaraju et al. 1992; Jensen 2000; Morishita 2001; Herron and James 2005; Weiss et al. 2009; Kay and Heron 2010; Chen et al. 2011). When using chemical control, it is necessary to rotate insecticide groups to prevent a buildup of resistance in thrips populations. The application of broad spectrum insecticides may upset control by natural enemies. Biological control programs that integrate the use of insecticides compatible with the conservation of natural populations of minute pirate bugs have been implemented for fruiting vegetables in Florida (Funderburk et al. 2011). Broad spectrum insecticides may also cause western flower thrips populations to increase due to a reduction in the competition from native flower thrips (Paini et al. 2008).

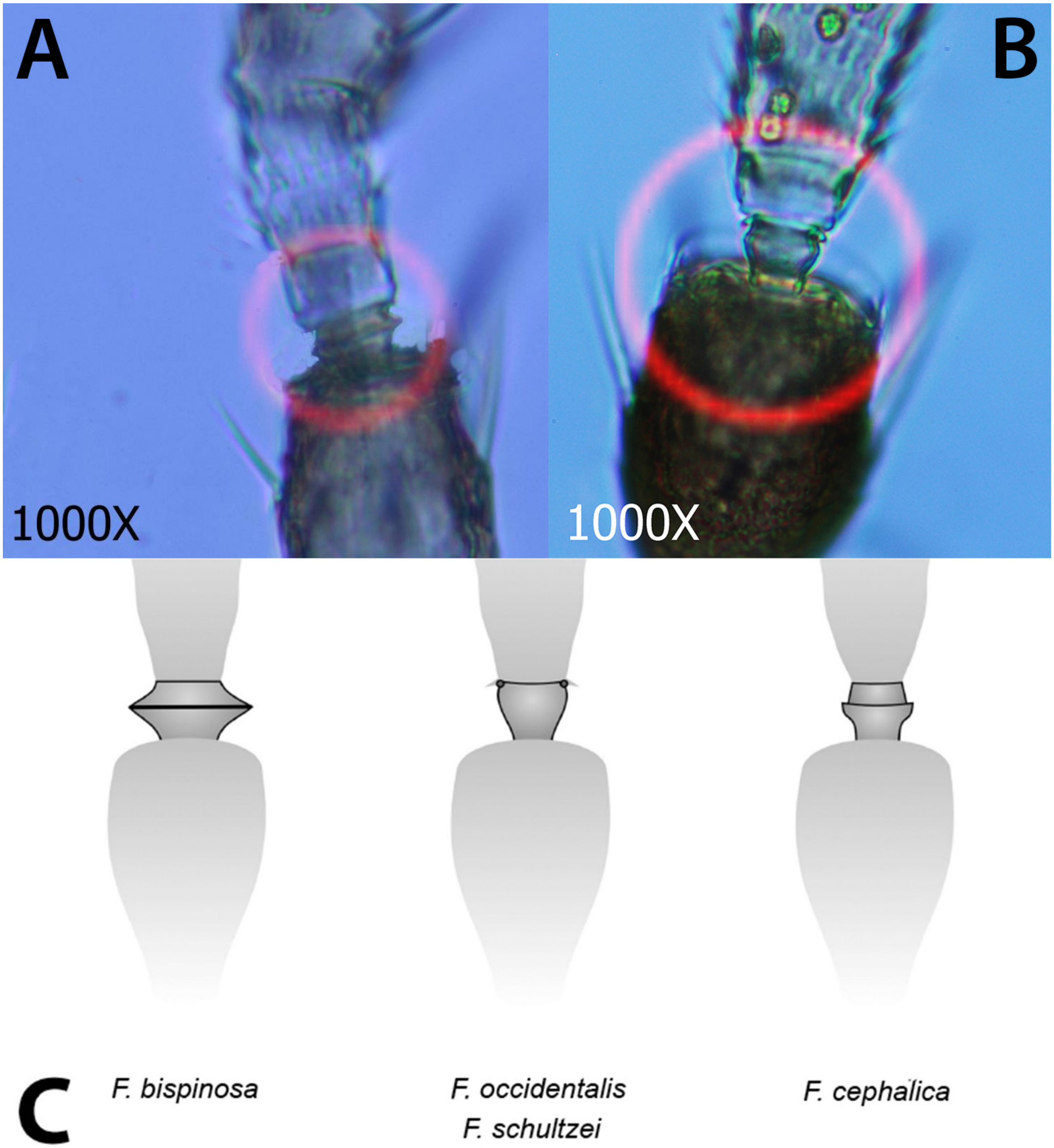

Figure 3. A) pedicel on 3rd antennal segment forming flange (characteristic of *F. bispinosa*). B) pedicel on 3rd antennal segment smooth, not forming flange (characteristic of *F. occidentalis* and *F. schultzei*). C) diagrammatic representation of pedicel on 3rd antennal segment on *F. bispinosa*, *F. occidentalis, F. schultzei* and *F. cephalica.*
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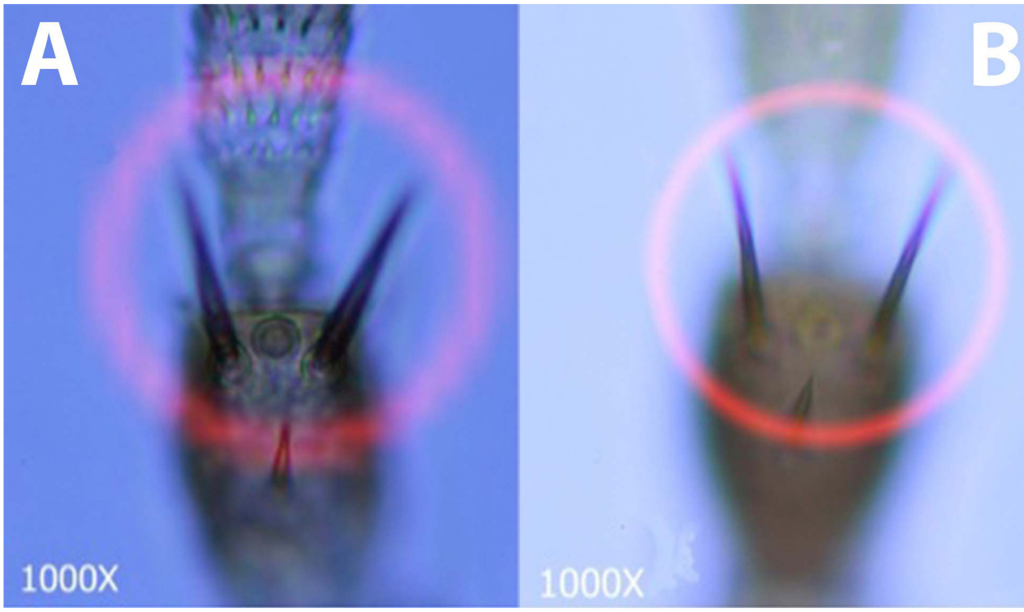

Figure 4. A) setae arising from 2nd antennal segment forming thick, heavy spines (characteristic of *F. bispinosa*). B) setae arising from 2nd antennal segment not forming thick, heavy spines (characteristic of *F. occidentalis* and *F. schultzei*).
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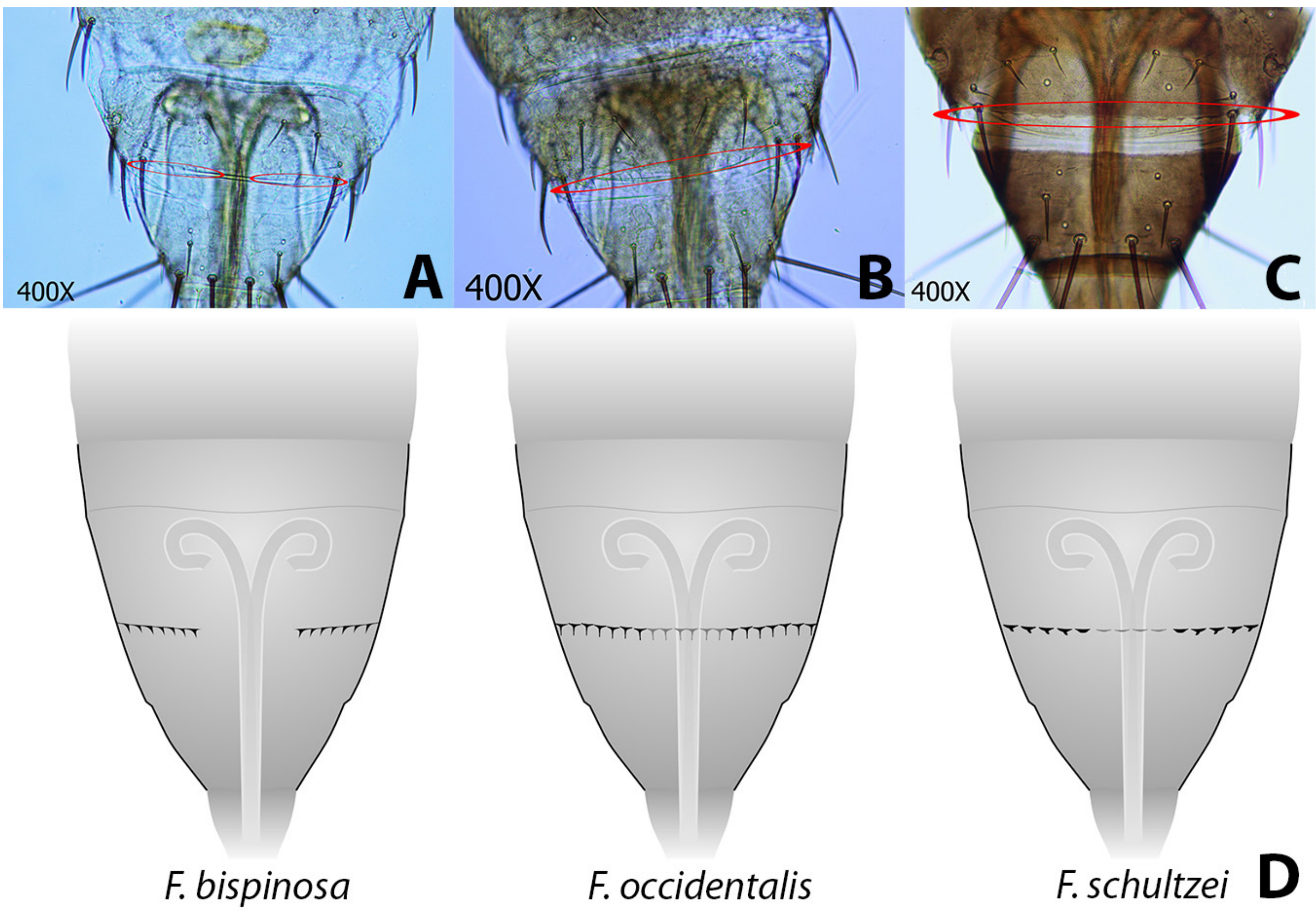

Figure 5. A) microtrichial comb on tergite VIII well developed and interrupted in center (characteristic of *F. bispinosa*). B) microtichial comb on tergite VIII well developed and not interrupted in center (characteristic of *F. occidentalis*). C) microtrichial comb on tergite VIII not well developed. (characteristic of *F. schultzei*). D) diagrammatic representation of michrotrichial comb on tergite VIII on *F. bispinosa*, *F. occidentalis,* and *F. schultzei*.
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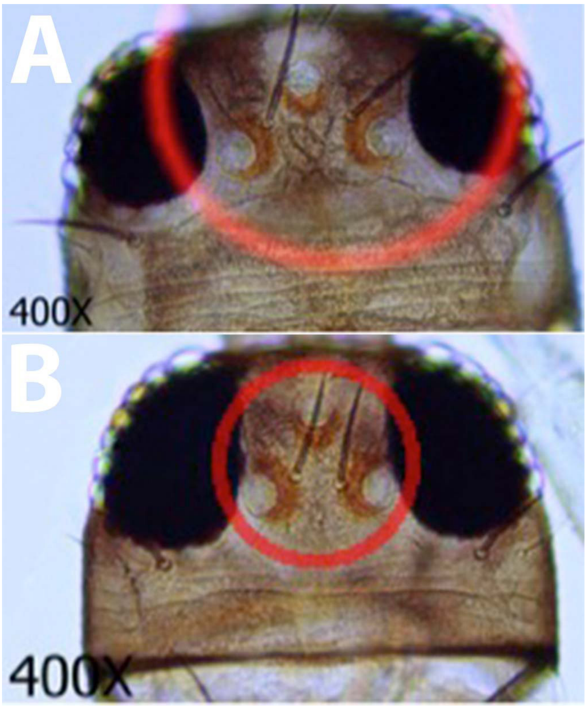

Figure 6. A) interocular setae arising far apart (characteristic of *F. bispinosa* and *F. occidentalis*). B) interocular setae arising close together (characteristic of *F. schultzei*).
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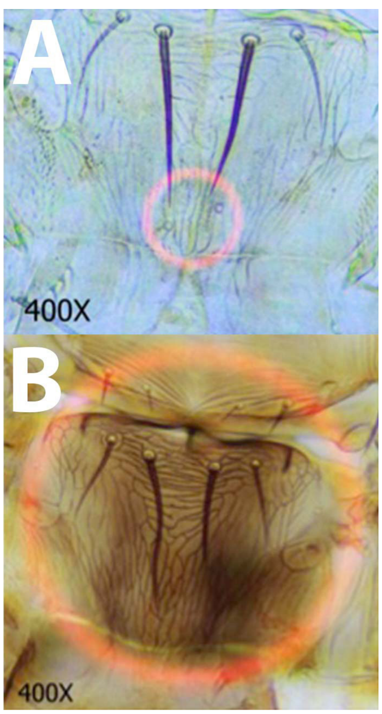

Figure 7. A) metanotal campaniform sensillae present (characteristic of *F. bispinosa* and *F. occidentalis*). B) metanotal campaniform sensillae absent (characteristic of *F. schultzei*).
Credits: JD Cluever

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Table 1. Some insecticides registered for control of thrips species on strawberry in Florida.

Active Ingredient	Trade name *	Group	MoA[t]	REI (hrs)	PHI days	notes
Acetamiprid	Assail 70 WP, 30 SG	neonicotinoid	4A	12	1	
Azadirachtin[O]	Aza-direct; Azatin O; Neemix 4.5% EC; Azatin XL	botanical extract	UN	4	0	Check label for optimal pH.
***Beauveria bassiana* strain GHA**	Botanigard 22 WP, 33 ES; Mycotrol O	biological	UN	4	0	Not compatible with some fungicides; some adjuvants and insecticide formulations can kill spores.
***Chromobacterium subtsugae* strain PRAA4-1**[O]	Grandevo	biological	UN	4	0	Do not combine in tank mix unless previous experience proves the combination compatible.
***Isaria fumosoroseus* (Apopka strain)**[O]	PFR-97 20%WDG	biological	UN	4	0	Do not mix or apply within 5 days of non-copper-based fungicides.
kaolin[O]	Surround	mineral	UN	4	0	Use of anti-foaming agents can interfere with coverage.
Malathion	Malathion 5EC, 8 Flowable	organophosphate	1B	12	3	
***Metarhizium anisopliae* strain F52**	MET52 EC	biological	UN	0 (soil) 4 (other)	0	Not compatible with fungicides.
Naled[r]	Dibrom 8-Enulsive	organophosphate	1B	48	1	Potential to bronze fruit under certain conditions; 7-day interval required between applications on Strawberry. Do not apply above 90°F.
Neem[O]	Trilogy	botanical extract	UN	4	0	
Pyrethrins & PBO	Evergreen EC 60-6; Pyronyl crop spray	pyrethrum	3A	12	0	
Pyrethrins[O]	PyGanic EC 5.0II	pyrethrum	3A	12	0	Buffer spray tank between pH 5.5 and 7.0.
Spinetoram	Radiant	spinosyn	5	4	1	pH between 5.0 and 9.0 recommended.
Spinosad[o]	Entrust	spinosyn	5	4	1	pH between 6.0 and 9.0 recommended.
Sulfoxaflor	Closer SC	sulfoxaflor (neonicotinoid)	4C	12	1	See pollinator advisory statement, suppression only.

* Trade names do not reflect recommendations
t = IRAC 2014
r=restricted use insecticide
o=OMRI listed